PATENT ABSTRACTS OF JAPAN

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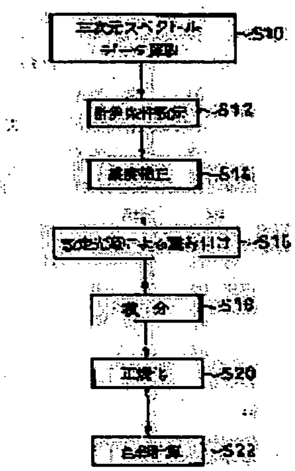
(54) DEVICE AND METHOD FOR MEASURING COLOR OF FLUORESCENT SUBSTANCE

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a method capable of appropriately and easily obtaining the color of a fluorescent substance.
SOLUTION: The method is characterized in being provided with a measurement process S10 for obtaining three-dimensional light intensity spectral data of a reference body and a sample by sequentially scanning light source lighting beam at a specified interval of wavelength using a lighting side spectroscope of a spectrophotometer, irradiating the reference body or the sample with each beam of selected wavelength, and scanning a desired region of wavelength for each selected wavelength selected by lighting side spectroscope using a detecting side spectroscope; and a calculation condition setting process S12 for specifying relative spectral distribution of relative intensity of lighting beam for evaluating the color. The data on the sample obtained in the process S10 are superposed (S16), according to the distribution of the relative intensity in the process S12, luminous intensity spectral data on the reference body and the sample are obtained (S18), under a specified lighting beam specified in the process S12, and luminous reflectivity spectral data of the sample with taking the reference body as a reference are obtained (S20), by dividing the data of the sample by the data of the reference body. The method is also provided with a calculation process S22 for obtaining psychophysical color specification for expressing the color of the fluorescent substance by scattered light and fluorescence of the sample under the specified lighting beam specified in the process S12 from the data obtained in the process S20.



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CLAIMS

[Claim(s)]
[Claim 1] A sample is replaced and installed in the predetermined measuring point of a spectrophotometer with standard lives. The wavelength scan of the illumination light from the light source is carried out one by one at intervals of predetermined wavelength using the lighting side spectroscope of this spectrophotometer. Irradiate the light of each selection wavelength at standard lives or a sample, and the detection side spectroscope of this spectrophotometer is used. The optical on-the-strength spectrum data of three dimensions carry out the wavelength scan of the wavelength field of a request on every selection wavelength in said lighting side spectroscope, and according to the fluorescence and the scattered light of standard lives under the illumination light from said light source, The measurement process which extracts the optical on-the-strength spectrum data of the three dimensions by the fluorescence and the scattered light of a sample, Using the relative intensity distribution information on the illumination light specified at the count conditioning process of specifying the relative intensity spectral distribution at the time of being based on the spectral distribution of the illumination light used at said measurement process of the illumination light used for evaluation of a color on the strength, and said count conditioning process Weighting of the Motomitsu Mitsugi on-the-strength spectrum data of the sample obtained at said measurement process is carried out. It asks for the luminescence on-the-strength spectrum data based on the scattered light and the fluorescence of a sample under the illumination light specified at said count conditioning process. The luminescence on-the-strength spectrum data of said sample by which weighting was carried out are ** (ed) by the luminescence on-the-strength spectrum data which were able to be obtained from the Motomitsu Mitsugi on-the-strength spectrum data of said standard lives. It asks for the luminescence reflection factor spectrum data as reflection factor spectrum data based on the scattered light and the fluorescence of a sample at the time of being based on standard lives. From the luminescence reflection factor spectrum data of the sample at the time of being based on said standard lives The fluorescence object color measuring method characterized by having the count process which calculates the colour stimulus specification expressing the fluorescence object color by the scattered light and the fluorescence of a sample at the time of being based on the color of standard lives under the illumination light specified at said count conditioning process.
[Claim 2] It is the fluorescence object color measuring method characterized by the tristimulus values X, Y, and Z as said colour stimulus specification being expressed by degree one account when using an XYZ color system for expressing said fluorescence object color in a fluorescence object color measuring method according to claim 1.
[Equation 1]

$$X = K\int R(\lambda_{EM})\cdot\bar{x}(\lambda_{EM})d\lambda_{EM}$$

$$Y = K\int R(\lambda_{EM})\cdot\bar{y}(\lambda_{EM})d\lambda_{EM}$$

$$Z = K\int R(\lambda_{EM})\cdot\bar{z}(\lambda_{EM})d\lambda_{EM}$$

$$W(\lambda_{EM}) = \int w(\lambda_{EX},\lambda_{EM})d\lambda_{EX}$$

$$F(\lambda_{EM}) = \int f(\lambda_{EX},\lambda_{EM})\cdot S(\lambda_{EX})d\lambda_{EX}$$

$$R(\lambda_{EM}) = F(\lambda_{EM}) / W(\lambda_{EM})$$

$$K = 100 / \int S(\lambda_{EM})\cdot y(\lambda_{EM})d\lambda_{EM}$$

It EX(s). here -- w(lambdaEX, lambdaEM): -- the selection wavelength lambda by said lighting side spectroscope obtained at said measurement process -- Optical on-the-strength spectrum data f of the three dimensions of the standard lives in selection wavelength lambdaEM by said detection side spectroscope (lambdaEX, lambdaEM) : Selection wavelength lambdaEX by said lighting side spectroscope obtained at said measurement process, optical on-the-strength spectrum data W (lambdaEM): of the three dimensions of the sample in selection wavelength lambdaEM by said detection side spectroscope -- luminescence on-the-strength spectrum data F(lambdaEM): of the standard lives in detection wavelength lambdaEM obtained at said count process -- the sample in detection wavelength lambdaEM obtained at said count process Luminescence on-the-strength spectrum data R under the illumination light specified at said count conditioning process (lambdaEM) : Were obtained at said count process. **(ed) the luminescence on-the-strength spectrum data of the sample in detection wavelength lambdaEM by the luminescence on-the-strength spectrum data of the standard lives in detection wavelength lambdaEM, and were obtained. The sample in detection wavelength lambdaEM, Normalization luminescence on-the-strength spectrum data S under the illumination light specified at said count conditioning process (lambdaEM) : The relative intensity spectral distribution x of the illumination light specified at said count conditioning process at the time of being based on the spectral distribution of the illumination light used at said measurement process on the strength, y, z The color equation K -- it can set to the XYZ color system used in case colour stimulus specification is calculated from luminescence reflection-factor spectrum data at the :aforementioned count process --: (lambdaEM) The normalization multiplier of the XYZ count used in case colour stimulus specification is calculated from luminescence reflection factor spectrum data at said count process

[Claim 3] The lighting side spectroscope which irradiates the standard lives or sample which chose the illumination light of request wavelength from the light from the continuation light source which generates the continuation light in the wavelength field to measure, and said continuation light source, and was put on the predetermined measuring point, The detection side spectroscope which obtains the light of request wavelength among said standard lives or the scattered light from a sample, and fluorescence, The wavelength scan of the selection wavelength in a lighting side spectroscope is carried out one by one at intervals of predetermined wavelength about the detector which detects the luminous intensity which carried out outgoing radiation of said detection side spectroscope, and standard lives and a sample. With a detection side spectroscope So that the optical on-the-strength spectrum data of the three dimensions in each selection wavelength in this lighting side spectroscope may be obtained A wavelength scan means to control the wavelength scan of said lighting side spectroscope and a detection side spectroscope, A data storage means to memorize the optical on-the-strength spectrum data of the three dimensions of standard lives based on the output value from said detector, and the optical on-the-strength spectrum data of the three dimensions of a sample, An illumination-light information storage

means to memorize the relative intensity distribution information at the time of being based on the spectral distribution of the illumination light of said continuation light source on the strength about the illumination light used for evaluating a color, A count conditioning means to specify the class of desired illumination light as said illumination-light information storage means out of the illumination light relative intensity distribution information was remembered to be, The relative intensity distribution information on the illumination light specified with said count conditioning means is acquired from said illumination-light information storage means. Using this relative intensity distribution information Weighting of the optical on-the-strength spectrum data of the three dimensions of the sample of said data storage means is carried out. It asks for the luminescence on-the-strength spectrum data based on the scattered light and the fluorescence of a sample under the illumination light specified with said count conditioning means. The luminescence on-the-strength spectrum data of said sample by which weighting was carried out are **(ed) by the luminescence on-the-strength spectrum data which were able to be obtained from the Motomitsu Mitsugi on-the-strength spectrum data of said standard lives. It asks for the luminescence reflection factor spectrum data as reflection factor spectrum data based on the scattered light and the fluorescence of a sample at the time of being based on said standard lives. From the luminescence reflection factor spectrum data based on the scattered light and the fluorescence of a sample at the time of being based on said standard lives The fluorescence object color measuring device characterized by having a count means to calculate the colour stimulus specification expressing the fluorescence object color by the scattered light and the fluorescence of a sample at the time of being based on the color of said standard lives under the illumination light specified with said count conditioning means.

[Claim 4] It is the fluorescence object color measuring device characterized by the tristimulus values X, Y, and Z as said colour stimulus specification being expressed by degree two accounts when using an XYZ color system for expressing said fluorescence object color in a fluorescence object color measuring device according to claim 3.

[Equation 2]

$$X = K\int R(\lambda_{EM})\cdot\bar{x}(\lambda_{EM})d\lambda_{EM}$$

$$Y = K\int R(\lambda_{EM})\cdot\bar{y}(\lambda_{EM})d\lambda_{EM}$$

$$Z = K\int R(\lambda_{EM})\cdot\bar{z}(\lambda_{EM})d\lambda_{EM}$$

$$W(\lambda_{EM}) = \int w(\lambda_{EX},\lambda_{EM})d\lambda_{EX}$$

$$F(\lambda_{EM}) = \int f(\lambda_{EX},\lambda_{EM})\cdot S(\lambda_{EX})d\lambda_{EX}$$

$$R(\lambda_{EM}) = F(\lambda_{EM}) / W(\lambda_{EM})$$

$$K = 100 / \int S(\lambda_{EM})\cdot y(\lambda_{EM})d\lambda_{EM}$$

It EX(s). here -- w(lambdaEX, lambdaEM): -- the selection wavelength lambda in said lighting side spectroscope -- Optical on-the-strength spectrum data f of the three dimensions of the standard lives of said data storage means in selection wavelength lambdaEM in said detection side spectroscope (lambdaEX, lambdaEM) : Selection wavelength lambdaEX in said lighting side spectroscope, To selection wavelength lambdaEM in a detection side spectroscope optical on-the-strength spectrum data W(lambdaEM): of the three dimensions of the sample of said data storage means which can be set -- luminescence on-the-strength spectrum data F(lambdaEM): of the standard lives in detection wavelength lambdaEM obtained with said count means -- the sample in detection wavelength lambdaEM obtained with said count means Luminescence on-the-strength spectrum data R under the illumination light

specified with said count conditioning means (lambdaEM) : Were obtained with said count means. ** (ed) the luminescence on-the-strength spectrum data of the sample in detection wavelength lambdaEM by the luminescence on-the-strength spectrum data of the standard lives in detection wavelength lambdaEM, and were obtained. The sample of detection wavelength lambdaEM, Normalization luminescence on-the-strength spectrum data S under the illumination light specified with said count conditioning means (lambdaEM) : The relative intensity spectral distribution x of the illumination light specified with said count conditioning means at the time of being based on the spectral distribution of the illumination light of said continuation light source on the strength, y, z The color equation K -- it can set to the XYZ color system used in case colour stimulus specification is calculated from luminescence reflection-factor spectrum data with the :aforementioned count means --: (lambdaEM) The normalization multiplier of the XYZ count used in case colour stimulus specification is calculated from luminescence reflection factor spectrum data with said count means

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[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to amelioration of a fluorescence object color measuring method and equipment especially a spectrum data extraction device, and the color computer style based on the spectrum data.
[0002]
[Description of the Prior Art] Generally, a wavelength field is absorbed in part among the light irradiated by the object, and **** of the color of an object becomes possible by discharging the remainder. However, there are some bodies which emit the so-called fluorescence, in this case, the additive mixture of colors of said scattered light and fluorescence will be carried out, they will be **** (ed), and the color of an object cannot be simply evaluated from a wavelength absorption property. Then, measurement of the color of the reflective body of fluorescence is conventionally performed by color coordinate systems, such as XYZ.
[0003] The measuring method of this fluorescence object color is specified to JIS Z 8717-1989, and when requiring accuracy also especially in it, for example, the 2 light-source fluorescence separation approach is used. The optical-system arrangement in the 2 light-source fluorescence separation approach is shown in drawing 1 . For example, there is a thing containing the electric eye 18 which measures the luminous intensity which carried out outgoing radiation of the monochromator 16 which carries out outgoing radiation of the desired homogeneous light among the scattered light from the working-standard white plate thru/or sample 14 in which the illumination light L1 from the light source 12 for measurement approximated to the spectral distribution of D65 and the light source 12 is put like the equipment 10 shown in this drawing (a), and a standard white plate or a sample 14, and fluorescence L2, and the monochromator 16.
[0004] moreover, it is based on the homogeneous-light irradiation equipment which consists of continuous source 12' and a monochromator 20, and the homogeneous light L1 like equipment 10' shown in this drawing (b) -- un--- a part for full wave Naganari of a working-standard white plate or the scattered light from a sample 14, and fluorescence L2 is collectively measured with a spectrum -- un--- a spectrum -- there is also a thing containing electric-eye 18' for observation.
[0005] Thus, by said 2 light-source fluorescence separation approach, by combining one monochromator, and the light source section and a light sensing portion in any case, and using it, two kinds of sample area-light light is used, and measurement of the spectral radiance of all spectral radiance factors and appearance separates and estimates a scattered-light component and a fluorescence component, and it is asking for the color by it. Here, by making said scattered-light component and fluorescence component into estimate, separation and when evaluating and asking for a color, the light source was always in agreement with the spectral distribution of D65, and the assumption that there was no fluctuation with time was used.
[0006] Moreover, when cutting the ultraviolet region of the illumination light, the working-standard leucoplast and the sample used the assumption of not emitting fluorescence, when it illuminated by the

sample illumination light. Thus, it was asking for the fluorescence object color as well as said 2 light-source fluorescence separation approach using presumption or quite bold approximation about other approaches specified to JIS Z 8717-1989.

[0007]

[Problem(s) to be Solved by the Invention] However, in said 2 light-source fluorescence separation approach made the strictest, the suitable technique in which the accuracy of said fluorescence object color presumption, repeatability, etc. could solve this although the room of an improvement was left behind did not exist. Moreover, how the color observed by the class of illumination light changing and detailed analysis were impossible.

[0008] Only the color which is visible at the time of the lighting of the daylight when the illumination light which was got blocked, for example, was approximated to the spectral distribution of D65 is used could be presumed, but the illumination light needed to be changed, remeasurement and a re-calculation needed to be redone from 1 to know the color when illuminating other light, and it was troublesome. This invention is made in view of the technical problem of said conventional technique, and the purpose is in offering the fluorescence object color measuring method and equipment which can ask for the fluorescence object color correctly and easily.

[0009]

[Means for Solving the Problem] As a result of this invention person's repeating examination wholeheartedly about improvement in said accuracy and repeatability, when the spectral distribution of the illumination light generated from the light source for measurement as a factor which is reducing the accuracy of a presumed result and repeatability cut the light of the ultraviolet region of the illumination light without fluctuation with time, it solved that standard lives and a sample were to have separated the reflective component and the fluorescence component by assumption of not emitting fluorescence.

[0010] According to this invention person, the spectral distribution of the same sample [the same equipment and] of the illumination light do not necessarily correspond, for example in the time when the lamp of the light source is old, and the new time. Moreover, there are some which emit fluorescence even in a visible region in standard lives and a sample. Then, this invention person extracts the optical on-the-strength spectrum data of the three dimensions by the scattered light and fluorescence, replacing with the technique of separating a scattered-light component and a fluorescence component using said conventionally general assumption, and evaluating a color, and actually performing the wavelength scan of the lighting side spectroscope of a spectrophotometer, and a detection side spectroscope.

[0011] And it came to complete a header and this invention for the improvement of the accuracy of said presumed result, repeatability, etc. being achieved by evaluating a color by count later mentioned from the optical on-the-strength spectrum data of such three dimensions collectively, without separating a scattered-light component and a fluorescence component. That is, the fluorescence object color measuring method which starts this invention in order to attain said purpose is characterized by having a measurement process, a count conditioning process, and a count process.

[0012] Said measurement process to the predetermined measuring point of a spectrophotometer here Standard lives, Replace and install a sample and the wavelength scan of the illumination light from the light source is carried out one by one at intervals of predetermined wavelength using the lighting side spectroscope of said spectrophotometer. Irradiate the light of each selection wavelength at standard lives or a sample, and the detection side spectroscope of said spectrophotometer is used. The wavelength scan of the wavelength field of a request on every selection wavelength in this lighting side spectroscope is carried out, and the optical on-the-strength spectrum data of the three dimensions by the fluorescence and the scattered light of standard lives under the illumination light from said light source and the optical on-the-strength spectrum data of the three dimensions by the fluorescence and the scattered light of a sample are extracted.

[0013] Moreover, said count conditioning process specifies the relative intensity spectral distribution at the time of being based on the spectral distribution of the illumination light used at said measurement process of the illumination light used for evaluation of a color on the strength. Said count process carries out weighting of the Motomitsu Mitsugi on-the-strength spectrum data of the sample obtained at said

measurement process using the relative intensity distribution information on the illumination light specified at said count conditioning process, and asks for the luminescence on-the-strength spectrum data based on the scattered light and the fluorescence of a sample under the illumination light specified at said count conditioning process. And the luminescence on-the-strength spectrum data of said sample by which weighting was carried out are **(ed) by the luminescence on-the-strength spectrum data which were able to be obtained from the optical on-the-strength spectrum data of the three dimensions of said standard lives, and it asks for the luminescence reflection factor spectrum data as reflection factor spectrum data based on the scattered light and the fluorescence of a sample at the time of being based on standard lives. Next, the colour stimulus specification expressing the fluorescence object color by the scattered light and the fluorescence of a sample at the time of being based on the color of said standard lives under the illumination light specified at said count conditioning process is calculated from the luminescence reflection factor spectrum data of the sample at the time of being based on the luminescence reflection factor spectrum data of said standard lives.

[0014] In addition, in this invention, when using an XYZ color system for expressing said fluorescence object color, being expressed by degree three accounts is suitable for the tristimulus values X, Y, and Z as said colour stimulus specification.

[Equation 3]

$$X = K\int R(\lambda_{EM})\cdot\bar{x}(\lambda_{EM})\,d\lambda_{EM}$$

$$Y = K\int R(\lambda_{EM})\cdot\bar{y}(\lambda_{EM})\,d\lambda_{EM}$$

$$Z = K\int R(\lambda_{EM})\cdot\bar{z}(\lambda_{EM})\,d\lambda_{EM}$$

$$W(\lambda_{EM}) = \int w(\lambda_{EX},\lambda_{EM})\,d\lambda_{EX}$$

$$F(\lambda_{EM}) = \int f(\lambda_{EX},\lambda_{EM})\cdot S(\lambda_{EX})\,d\lambda_{EX}$$

$$R(\lambda_{EM}) = {F(\lambda_{EM})}/{W(\lambda_{EM})}$$

$$K = {100}/{\int S(\lambda_{EM})\cdot y(\lambda_{EM})\,d\lambda_{EM}}$$

[0015] It EX(s). here -- w(lambdaEX, lambdaEM): -- the selection wavelength lambda in said lighting side spectroscope obtained at said measurement process -- Optical on-the-strength spectrum data f of the three dimensions of the standard lives in selection wavelength lambdaEM in said detection side spectroscope (lambdaEX, lambdaEM) : Selection wavelength lambdaEX in said lighting side spectroscope obtained at said measurement process, optical on-the-strength spectrum data W (lambdaEM): of the three dimensions of the sample in selection wavelength lambdaEM in a detection side spectroscope -- luminescence on-the-strength spectrum data F(lambdaEM): of the standard lives in detection wavelength lambdaEM obtained at said count process -- the sample in detection wavelength lambdaEM obtained at said count process Luminescence on-the-strength spectrum data R under the illumination light specified at said count conditioning process (lambdaEM) : Were obtained at said count process. **(ed) the luminescence on-the-strength spectrum data of the sample in detection wavelength lambdaEM by the luminescence on-the-strength spectrum data of the standard lives in detection wavelength lambdaEM, and were obtained. The sample in detection side wavelength lambdaEM, Normalization luminescence on-the-strength spectrum data S under the illumination light specified at said count conditioning process (lambdaEM) : The relative intensity spectral distribution x of the illumination light specified at said count conditioning process at the time of being based on the spectral distribution of the illumination light used at said measurement process on the strength, y, z The color equation K -- it can set to the XYZ color system used in case colour stimulus specification is

calculated from luminescence reflection-factor spectrum data at the :aforementioned count process --: (lambdaEM) The normalization multiplier of the XYZ count used in case colour stimulus specification is calculated from luminescence reflection factor spectrum data at said count process

[0016] Moreover, the fluorescence object color measuring device applied to this invention in order to attain said purpose is characterized by having the continuation light source, a lighting side spectroscope, a detection side spectroscope, a detector, a wavelength scan means, a data storage means, an illumination-light information storage means, a count conditioning means, and a count means. Here, said continuation light source generates the continuation light in the wavelength field to measure. Moreover, said lighting side spectroscope chooses the illumination light of request wavelength from the illumination light from said continuation light source, and irradiates the standard lives or sample put on the predetermined measuring point. Said detection side spectroscope obtains the light of request wavelength among said standard lives or the scattered light from a sample, and fluorescence.

[0017] Said detector detects the luminous intensity which carried out outgoing radiation of said fluorescence side spectroscope. Said wavelength scan means controls the wavelength scan of said lighting side spectroscope and a detection side spectroscope so that the wavelength scan of the selection wavelength in a lighting side spectroscope is carried out one by one at intervals of predetermined wavelength and the optical on-the-strength spectrum data of the three dimensions in each wavelength chosen by the detection side spectroscope with this lighting side spectroscope are obtained about standard lives and a sample.

[0018] Said data storage means memorizes the optical on-the-strength spectrum data of the three dimensions of standard lives based on the output value from said detector, and the optical on-the-strength spectrum data of the three dimensions of a sample. Said illumination-light information storage means memorizes the relative intensity distribution information at the time of being based on the spectral distribution of the illumination light of said continuation light source on the strength about the illumination light used for evaluation of a color. Said count conditioning means specifies the class of illumination light used for evaluation of a color out of the illumination light relative intensity distribution information was remembered to be by said illumination-light information storage means.

[0019] Said count means acquires the relative intensity distribution information on the illumination light specified with said count conditioning means from said illumination-light information storage means, using this relative intensity distribution information, carries out weighting of the optical on-the-strength spectrum data of the three dimensions of the sample of said data storage means, and asks for the luminescence on-the-strength spectrum data based on the scattered light and the fluorescence of a sample under the illumination light specified with said count conditioning means. And the luminescence on-the-strength spectrum data of said sample by which weighting was carried out are **(ed) by the luminescence on-the-strength spectrum data which were able to be obtained from the optical on-the-strength spectrum data of the three dimensions of said standard lives, and it asks for the luminescence reflection factor spectrum data as reflection factor spectrum data based on the scattered light and the fluorescence of a sample at the time of being based on said standard lives. Next, the colour stimulus specification expressing the fluorescence object color by the scattered light and the fluorescence of a sample at the time of being based on the color of said standard lives under the illumination light specified with said count conditioning means is calculated from the luminescence reflection factor spectrum data based on the scattered light and the fluorescence of a sample at the time of being based on said standard lives.

[0020] In addition, in this invention, when using an XYZ color system for expressing said fluorescence object color, being expressed by degree four accounts is suitable for the tristimulus values X, Y, and Z as said colour stimulus specification.

[Equation 4]

$$X = K\int R(\lambda_{EM}) \cdot \bar{x}(\lambda_{EM}) d\lambda_{EM}$$

$$Y = K\int R(\lambda_{EM}) \cdot \bar{y}(\lambda_{EM}) d\lambda_{EM}$$

$$Z = K\int R(\lambda_{EM}) \cdot \bar{z}(\lambda_{EM}) d\lambda_{EM}$$

$$W(\lambda_{EM}) = \int w(\lambda_{EX}, \lambda_{EM}) d\lambda_{EX}$$

$$F(\lambda_{EM}) = \int f(\lambda_{EX}, \lambda_{EM}) \cdot S(\lambda_{EX}) d\lambda_{EX}$$

$$R(\lambda_{EM}) = {F(\lambda_{EM})}/{W(\lambda_{EM})}$$

$$K = {100}/{\int S(\lambda_{EM}) \cdot y(\lambda_{EM}) d\lambda_{EM}}$$

[0021] It EX(s). here -- w(lambdaEX, lambdaEM): -- the selection wavelength lambda in said lighting side spectroscope -- Optical on-the-strength spectrum data f of the three dimensions of the standard lives of said data storage means in selection wavelength lambdaEM in said detection side spectroscope (lambdaEX, lambdaEM) : Selection wavelength lambdaEX in said lighting side spectroscope, To selection wavelength lambdaEM in said detection side spectroscope optical on-the-strength spectrum data W(lambdaEM): of the three dimensions of the sample of said data storage means which can be set -- luminescence on-the-strength spectrum data F(lambdaEM): of the standard lives in detection wavelength lambdaEM obtained with said count means -- the sample in detection wavelength lambdaEM obtained with said count means Luminescence on-the-strength spectrum data R based on the illumination light specified with said count conditioning means (lambdaEM) : Were obtained with said count means. The standard lives in detection wavelength lambdaEM carried out luminescence on-the-strength spectrum data ** of the luminescence on-the-strength spectrum data of the sample in detection wavelength lambdaEM, and were obtained. The sample in detection wavelength lambdaEM, Normalization luminescence on-the-strength spectrum data S under the illumination light specified with said count conditioning means (lambdaEM) : The relative intensity spectral distribution x of the illumination light specified with said count conditioning means at the time of being based on the spectral distribution on the strength over the illumination light of said continuation light source, y, z The color equation K -- it can set to the XYZ color system used in case colour stimulus specification is calculated from luminescence reflection-factor spectrum data with the :aforementioned count means --: (lambdaEM) The normalization multiplier of the XYZ count used in case colour stimulus specification is calculated from luminescence reflection factor spectrum data with said count means
[0022] With the count conditioning process and means which are said here, if it is required conditions in case the color other than the illumination light used for evaluation of a color is calculated, it will carry out to the ability of other conditions, for example, an angle of visibility, wavelength spacing, etc. to be set up. Moreover, the fluorescence and the scattered light which are said here are not what observed [the sample by the illumination light, or / of standard lives] those light from specular reflection, and what was observed from [other] arbitration is said.
[0023] Moreover, luminescence said here means the sample by the illumination light, or the fluorescence from standard lives rather than means the light emitted from a certain emitter itself. Moreover, the luminescence on-the-strength spectrum data said here mean a thing including what is depended on the sample by the illumination light, or the scattered light from standard lives rather than mean what is depended only on the sample by the illumination light, or fluorescence from standard lives. Moreover, the luminescence reflection factor spectrum data said here mean a thing including what is depended only on the sample by the illumination light, or fluorescence from standard lives, and the thing depended on the sample by the illumination light, or the scattered light from standard lives.

[0024]
[Embodiment of the Invention] Hereafter, the suitable operation gestalt of this invention is explained based on a drawing. The outline configuration of the fluorescence object color measuring device concerning 1 operation gestalt of this invention is shown in drawing 2 . In addition, a sign 100 is added and shown in said drawing 1 and a corresponding part, and explanation is omitted.
[0025] The fluorescence object color measuring device 110 shown in this drawing contains a spectrophotofluorometer (spectrophotometer) 122 and a computer (count means) 124. Said spectrophotofluorometer 122 contains the continuation light source 112, the excitation side spectroscope (lighting side spectroscope) 120, the fluorescence side spectroscope (detection side spectroscope) 116, and a detector 118. Here, said continuation light source 112 generates the continuation light in the wavelength field to measure. Moreover, said excitation side spectroscope 120 chooses the illumination light L1 of request wavelength from the light from the light source 112, and irradiates the white plate (standard lives) or sample 114 put on the predetermined measuring point.
[0026] Said fluorescence side spectroscope 116 obtains the light of request wavelength out of the light L2 by the scattered light and the fluorescence from said white plate or a sample 114. Said detector 118 detects the luminous intensity which carried out outgoing radiation of the fluorescence side spectroscope 116. Said computer 124 contains the data storage means 126, the illumination-light information storage means 128, the count conditioning means 130, and CPU132.
[0027] Said data storage means 126 memorizes the white plate obtained by carrying out the wavelength scan of the excitation side spectroscope 120 of a spectrophotofluorometer 122, and the fluorescence side spectroscope 116, and the three-dimensions fluorescence-spectrum data (optical on-the-strength spectrum data of three dimensions) of a sample. Said illumination-light information storage means 128 memorizes beforehand the on-the-strength spectral-distribution information at the time of being based on the relative intensity spectral distribution of the various illumination light used for evaluation of a color, i.e., the spectral distribution of the illumination light of said continuation light source on the strength.
[0028] Said count conditioning means 130 sets up the color coordinate system which is needed in the case of count of a color, an angle of visibility, the illumination light, wavelength spacing, etc. In case said CPU132 calculates a color, it acquires the relative intensity distribution information on the illumination light specified with the count conditioning means 130 from the illumination-light information storage means 128. And this CPU132 carries out weighting of the three-dimensions fluorescence-spectrum data of the sample of the data storage means 126 using the relative intensity distribution information on this assignment illumination light. Thereby, the luminescence on-the-strength spectrum data of the sample under the assignment illumination light are obtained.
[0029] Moreover, this CPU132 calculates the luminescence on-the-strength spectrum data of a white plate from the three-dimensions fluorescence-spectrum data of the white plate of the data storage means 126. This CPU132 asks for the ratio of the luminescence on-the-strength spectrum data of the white plate obtained as mentioned above, and the luminescence on-the-strength spectrum data of a sample, i.e., equivalence reflectance spectrum data.
[0030] And this CPU132 expresses the fluorescence object color by the scattered light and the fluorescence of a sample under said assignment illumination light with the tristimulus values of an XYZ color system based on this equivalence reflectance spectrum data. In addition, a computer 124 and the wavelength scan means 134,136 perform the wavelength scan of the excitation side spectroscope 120 and the fluorescence side spectroscope 116, and they control the wavelength scan of the excitation side spectroscope 120 and the fluorescence side spectroscope 116 so that the three-dimensions fluorescence-spectrum data of the wavelength range of desired are obtained.
[0031] the fluorescence object color measuring device 110 concerning this operation gestalt -- an outline -- it is constituted as mentioned above and the operation is explained below. First, when asking for the fluorescence object color, the spectral distribution of the illumination light from the light source on the strength were always in agreement with the spectral distribution of D65 on the strength, and the assumption that there was no fluctuation with time was usually used.

[0032] Moreover, when cutting the ultraviolet region of the illumination light, when it illuminated by the sample illumination light, using the assumption of not emitting fluorescence, the standard leucoplast and the sample separated the scattered-light component and the fluorescence component, and were evaluating the color. However, when a scattered-light component and a fluorescence component are separated using such an assumption, much more improvement of the accuracy of a presumed result, repeatability, etc. cannot be desired.
[0033] So, with this operation gestalt, the three-dimensions fluorescence-spectrum data based on the scattered light and fluorescence are extracted, replacing with said conventional method, i.e., the technique of separating a scattered-light component and a fluorescence component using said conventional assumption, and evaluating a color, and actually performing the wavelength scan of the excitation side spectroscope 120 of a spectrophotofluorometer 122, and the fluorescence side spectroscope 116, in order to aim at the improvement of the accuracy of a presumed result, repeatability, etc. And we decided to evaluate a color by count later mentioned from such three-dimensions fluorescence-spectrum data collectively, without separating a scattered-light component and a fluorescence component. It explains referring to drawing 3 about the concrete operation below.
[0034] The wavelength scan of the excitation side spectroscope 120 of the three-dimensions fluorescence-spectrum data extraction spectrophotofluorometer 122 and the fluorescence side spectroscope 116 is performed, and the three-dimensions fluorescence-spectrum data which include the effect of the scattered light of a white plate and fluorescence on suitable conditions are measured. Then, this white plate is transposed to a sample and three-dimensions fluorescence-spectrum data (refer to drawing 4) including the effect of the scattered light of a sample and fluorescence are measured (S10).
[0035] Thus, the scattered light and fluorescence are included in the extracted three-dimensions fluorescence-spectrum data. In addition, in order to extract such three-dimensions fluorescence-spectrum data, the selective excitation wavelength in the excitation side spectroscope 120 is changed at intervals of 300nm, 310nm, 320, --780nm, and a fixed step and 10nm, the wavelength scan of the fluorescence side spectroscope 116 is carried out, and the fluorescence spectrum in each selective excitation wavelength is measured.
[0036] For example, with this operation gestalt, excitation wavelength spacing in the excitation side spectroscope 120 is set to 380 to 780nm. And excitation wavelength spacing in the excitation side spectroscope 120 is set to 5nm or 10nm, and fluorescence wavelength spacing in a fluorescence side spectroscope is set to 1nm. Excitation and a fluorescence bandwidth presuppose that it is the same, and is made in agreement with excitation wavelength spacing.
[0037] The fluorescence wavelength range by the fluorescence side spectroscope 116 is set to excitation wavelength-bandwidth x2- excitation wavelength x2-bandwidth x2. However, the maximum range extracts three-dimensions fluorescence-spectrum data as 380nm - 780nm.
[0038] A computer 124 specifies count conditions, such as a color coordinate system, an angle of visibility, the light source (illumination light), and wavelength spacing, after count conditioning and the three-dimensions spectrum data extraction by the spectrophotofluorometer 122 (S12).
[0039] (1) The selection computer 124 of a color coordinate system chooses the color coordinate system expressing the fluorescence object color of a sample. For example, suppose that it is selectable from XYZ, Lab, L*a*b*, L*u*b*, L*H*C*, and Munsell.
[0040] (2) The angle-of-visibility computer 124 chooses from the three-dimensions fluorescence-spectrum data of a sample the angle of visibility at the time of calculating the tristimulus values (XYZ) of the fluorescence object color, and the angle stretched to a watcher's eyes. For example, suppose twice that it is selectable from a visual field and a 10-degree visual field.
[0041] (3) The selection computer 124 of the illumination light chooses the class of illumination light at the time of calculating the tristimulus values of the fluorescence object color from the three-dimensions fluorescence-spectrum data of a sample. For example, suppose that it is selectable from the standard illuminant A set to JIS Z 8720-1983, a standard illuminant D65, standard illuminant C, and an auxiliary standard illuminant B.
[0042] (4) Choose from the three-dimensions fluorescence-spectrum data of a wavelength spacing

sample wavelength spacing at the time of calculating the tristimulus values of the fluorescence object color, i.e., wavelength spacing in the addition mentioned later. For example, suppose that it is selectable from 5nm and 10nm.

[0043] The correction-by-sensitiveness computer 124 of an excitation side spectroscope normalizes the obtained three-dimensions fluorescence-spectrum data by excitation light reinforcement and the sensibility of the excitation side spectroscope 120 (S14). That is, with this operation gestalt, it has the spectroscope 120,116 which became independent to the fluorescence and excitation side. For this reason, if the signal by the side of Ex (lambdaEX) and fluorescence is set to Em (lambdaEM) for the signal by the side of excitation, the fluorescence intensity F (lambdaEX, lambdaEM) recorded will serve as a value shown in degree five accounts. If there is no wavelength property in the excitation side spectroscope 120, the direct use of this value can be carried out, but since sensibility changes with wavelength in fact, such amendment is performed with this operation gestalt.

[0044]

[Equation 5] F(lambdaEX, lambdaEM) =Em(lambdaEM)/Ex (lambdaEX)

It amends by multiplying by the sensibility PD of the excitation side spectroscope in wavelength lambdaEX (lambdaEX).

[0045] The weighting computer 124 by the illumination light used for evaluation of a color performs weighting in the relative intensity spectral distribution of the selected illumination light (S16). In addition, relative intensity distribution of this illumination light, i.e., energy distribution, can use things, such as standard illuminant A set to JIS, a standard illuminant D65, standard illuminant C, and an auxiliary standard illuminant B, as they are.

[0046] A computer 124 multiplies the three-dimensions fluorescence-spectrum data of the sample of the data storage means 126 by the relative intensity of each wavelength of the illumination light chosen as mentioned above, and performs weighting by the illumination light used for evaluation of a color. The fluorescence spectrum in each excitation wavelength when considering as the illumination light as which excitation energy was specified by this can be obtained. In addition, about a white plate, weighting by the illumination light chosen by count conditioning does not carry out.

[0047] The data in each fluorescence wavelength which carried out weighting are added at intervals of the wavelength specified by said count conditioning (S18), and the integral computer 124 uses them as 380nm - 780nm three-dimensions fluorescence-spectrum data. The luminescence on-the-strength spectrum data when considering as the illumination light as which excitation energy was specified by this processing can be obtained.

[0048] The luminescence on-the-strength spectrum data which carried out the normalization aforementioned guide peg show the luminescence reinforcement in each wavelength including the scattered light by the selected illumination light, i.e., luminescence on-the-strength spectrum data. The spectrum data which **(ed) the luminescence on-the-strength spectrum data of a sample by the luminescence on-the-strength spectrum data of a white plate turn into luminescence on-the-strength spectrum data which normalized the sample including fluorescence (S20).

[0049] Weighting of the illumination light which uses for evaluation of a color the luminescence on-the-strength spectrum data of the sample obtained according to the above integrals is carried out. If the luminescence on-the-strength spectrum data of a white plate are obtained, the ratio will serve as a reflection factor and equivalence. With this operation gestalt, this is called equivalence reflectance spectrum data.

[0050] About this equivalence reflectance spectrum data, at intervals of the angle of visibility set up by count conditioning, and wavelength, the color count computer 124 computes the tristimulus values X, Y, and Z of an XYZ color system, and displays them by the specified color coordinate system. The colour stimulus specification which expresses the object color by the scattered light and the fluorescence under the illumination light specified by said count conditioning from this normalization equivalence reflectance spectrum data and color matching function is calculated (S22).

[0051] In addition, the tristimulus values X, Y, and Z of the fluorescence object color in an XYZ color system are given in degree six accounts.

[Equation 6]

$$X = K\int_{380}^{780} R(\lambda_{EM})\cdot\bar{x}(\lambda_{EM})\,d\lambda_{EM}$$

$$Y = K\int_{380}^{780} R(\lambda_{EM})\cdot\bar{y}(\lambda_{EM})\,d\lambda_{EM}$$

$$Z = K\int_{380}^{780} R(\lambda_{EM})\cdot\bar{z}(\lambda_{EM})\,d\lambda_{EM}$$

$$W(\lambda_{EM}) = \int_{300}^{780} w(\lambda_{EX},\lambda_{EM})\,d\lambda_{EX}$$

$$F(\lambda_{EM}) = \int_{300}^{780} f(\lambda_{EX},\lambda_{EM})\cdot S(\lambda_{EX})\,d\lambda_{EX}$$

$$R(\lambda_{EM}) = F(\lambda_{EM}) \Big/ W(\lambda_{EM})$$

$$K = 100 \Big/ \int_{380}^{780} S(\lambda_{EM})\cdot y(\lambda_{EM})\,d\lambda_{EM}$$

[0052] It EX(s). here -- w(lambdaEX, lambdaEM): -- the excitation wavelength lambda memorized by said data storage means 126 -- Three-dimensions fluorescence-spectrum data of the white plate of fluorescence wavelength lambdaEM, f (lambdaEX, lambdaEM) : Excitation wavelength lambdaEX memorized by said data storage means 126, Three-dimensions fluorescence-spectrum data of the sample of fluorescence wavelength lambdaEM, W (lambdaEM) : The luminescence on-the-strength spectrum data of the white plate of wavelength lambdaEM obtained by said integral, F (lambdaEM) : Said weighting, the luminescence on-the-strength spectrum data based on the illumination light of the sample of wavelength lambdaEM obtained by the integral, R (lambdaEM) : The normalization luminescence on-the-strength spectrum data based on the illumination light of the sample of wavelength lambdaEM obtained by said normalization, S(lambdaEM): -- the wavelength dispersion (relative intensity spectral distribution) of the illumination light used for said color count, x, y, and z(lambdaEM): -- a color equation -- it can set to the XYZ color system in said color count -- and K: -- the normalization multiplier of the XYZ count by said color count.

[0053] In addition, in this operation gestalt, three-dimensions fluorescence-spectrum data need to be amended by excitation energy regularity. Thus, according to the fluorescence object color measuring device 110 concerning this operation gestalt, the wavelength scan of the excitation side spectroscope 120 of a spectrophotofluorometer 122 and the fluorescence side spectroscope 116 is actually performed, the three-dimensions fluorescence-spectrum data based on the scattered light and the fluorescence of a white plate and a sample 14 are extracted, and it memorizes for the data storage means 126.

[0054] Thereby, according to the color coordinate system specified by count conditioning, a visual field, the light source (illumination light), and wavelength spacing, we decided to make computable colour stimulus specification which expresses the fluorescence object color from a white plate and the three-dimensions fluorescence-spectrum data of a sample by computer 124. Consequently, according to the fluorescence object color measuring device 110 concerning this operation gestalt, the three-dimensions fluorescence-spectrum data based on the scattered light and the fluorescence which actually measured with the spectrophotofluorometer and were acquired are extractable.

[0055] And since a color can be evaluated collectively, without separating a scattered-light component and a fluorescence component from such three-dimensions fluorescence-spectrum data by count, as compared with the case where separated the scattered-light component and the fluorescence component using the conventional method, i.e., a conventionally general assumption, and a color is evaluated, improvement in the accuracy of the presumed result of a color is achieved.

[0056] When the illumination light approximated to the spectral distribution of D65 was used when the conventional method was used here for example, only the color which is visible when the daylight is illuminated could be presumed, but the illumination light actually needed to be changed to know the

color when illuminating other light, a series of processes of remeasurement and a re-calculation needed to be redone from 1, and it was troublesome.

[0057] On the other hand, it is possible to ask only by the re-calculation by the computer 124, without according to the fluorescence object color measuring device 110 concerning this operation gestalt, measuring again the color when changing the illumination light which evaluates a color by actually changing the illumination light, once it memorizes a white plate and the three-dimensions fluorescence-spectrum data of a sample for the data storage means 126.

[0058] Therefore, presumption becomes possible easily only by count about the color when seeing by other illumination light. And since the color when changing the illumination light can be searched for only by the re-calculation by the computer 124, without measuring again by actually changing the illumination light, it is not influenced of degradation of the lamp of the light source etc. Thereby, according to the fluorescence object color measuring device 110 concerning this operation gestalt, as compared with the conventional method, presumption becomes possible more easily and proper about the color by the scattered light and the fluorescence under various illumination light.

[0059] According to the fluorescence object color measuring device 110 applied to this operation gestalt as mentioned above If the wavelength scan of the excitation side of a spectrophotofluorometer 122 and the fluorescence side spectroscope 120,116 is performed and the three-dimensions fluorescence-spectrum data based on the scattered light and the fluorescence of a white plate and a sample are extracted for the data storage means 126 According to the color coordinate system specified at the count conditioning process, a visual field, the light source, wavelength spacing, etc., we decided to make computable the fluorescence object color by the scattered light and the fluorescence of a sample under the desired illumination light from the white plate in the data storage means 126, and the three-dimensions fluorescence-spectrum data of a sample.

[0060] Consequently, according to the fluorescence object color measuring device 110 concerning this operation gestalt, the three-dimensions fluorescence-spectrum data based on the scattered light and the fluorescence which were actually acquired using the spectrophotofluorometer are extractable. And since a color can be evaluated collectively, without separating a scattered-light component and a fluorescence component from such three-dimensions fluorescence-spectrum data by count, as compared with the case where separated the scattered-light component and the fluorescence component using the conventional method, i.e., a conventionally general assumption, and a color is evaluated, improvement in the accuracy of the presumed result of a color is achieved.

[0061] And according to the fluorescence object color measuring device 110 concerning this operation gestalt, it can ask only by the re-calculation by the computer 124, without measuring the color when changing the illumination light again by actually changing the illumination light, since a white plate and the three-dimensions fluorescence-spectrum data of a sample are extracted for the data storage means 126. Therefore, the color when seeing by various illumination light can be presumed only by count.

[0062] In addition, although said configuration explained the example which used the XYZ color system for expressing the fluorescence object color, it is not limited to this and the fluorescence object color measuring method and equipment of this invention can also use other color coordinate systems. Moreover, said configuration explained the example which used the spectrophotofluorometer as a spectrophotometer of this invention. Here, originally a spectrophotofluorometer observes only fluorescence.

[0063] However, with this operation gestalt, both scattered light of the sample by the illumination light or standard lives and fluorescence are observed using a spectrophotofluorometer. Therefore, the excitation wavelength chosen with the excitation side spectroscope as used in the field of this operation gestalt says the wavelength of the illumination light. Moreover, the fluorescence wavelength chosen with the fluorescence side spectroscope as used in the field of this operation gestalt says the wavelength of light including the fluorescence and the scattered light from a sample or a white plate rather than says the fluorescence wavelength itself.

[0064] Moreover, said configuration explained the example which expressed the Motomitsu Mitsugi on-the-strength spectrum data of this invention as three-dimensions fluorescence-spectrum data. Here,

originally, fluorescence-spectrum data observe only fluorescence and are obtained. However, the three-dimensions fluorescence-spectrum data as used in the field of this operation gestalt mean a thing including what is depended on the scattered light of the sample by the illumination light, or standard lives rather than mean what is depended only on the fluorescence of the sample by the illumination light, or standard lives.

[0065]

[Effect of the Invention] According to the fluorescence object color measuring method and equipment which are applied to this invention as mentioned above The wavelength scan of a lighting side spectroscope and a detection side spectroscope is actually performed using a spectrophotometer. Replace standard lives and a sample and the optical on-the-strength spectrum data of the three dimensions by the scattered light and fluorescence are extracted (measurement process). The relative intensity spectral distribution of the illumination light used for evaluation of a color are specified (a count conditioning process and means). By count from the optical on-the-strength spectrum data of the three dimensions of standard lives, and the optical on-the-strength spectrum data of the three dimensions of a sample We decided to calculate the colour stimulus specification expressing the object color by the scattered light and the fluorescence under the desired illumination light (a count process and means). Consequently, according to the fluorescence object color measuring method and equipment concerning this invention, the optical on-the-strength spectrum data of the three dimensions by the scattered light and the fluorescence which were acquired using the spectrophotometer actually equipped with the lighting side spectroscope and the detection side spectroscope are extractable. And since a color can be evaluated collectively, without separating a scattered-light component and a fluorescence component from the optical on-the-strength spectrum data of such three dimensions by count, as compared with the case where separated the scattered-light component and the fluorescence component using the conventional method, i.e., a conventionally general assumption, and a color is evaluated, improvement in the accuracy of the presumed result of a color is achieved. Furthermore, according to the fluorescence object color measuring method and equipment concerning this invention, since the optical on-the-strength spectrum data of the three dimensions of standard lives and a sample are memorized for the data storage means, it can ask for change of the color when changing the illumination light used for evaluation of a color easily only by re-calculation, without actually measuring again. Therefore, according to the fluorescence object color measuring method and equipment concerning this invention, since the color under various illumination light can be presumed only by count, it is not influenced of degradation of the lamp of the light source which generates the desired illumination light etc. Thereby, while being able to evaluate the color under various illumination light easily, improvement in repeatability is achieved.

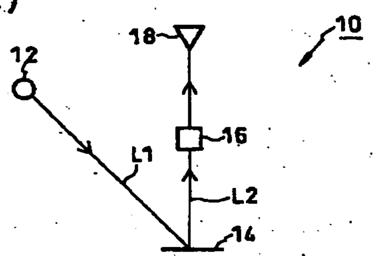
[Translation done.]

* NOTICES *

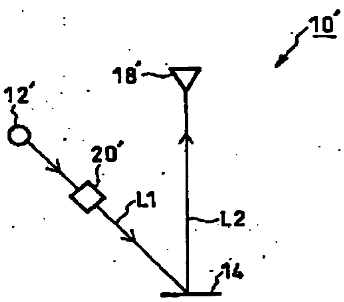
DRAWINGS

[Drawing 1]

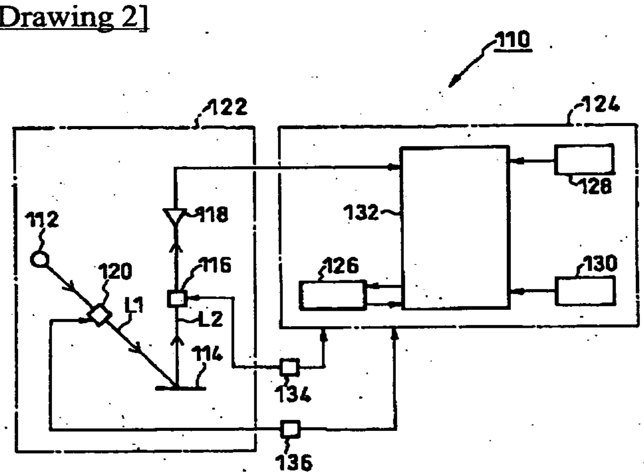
(a)



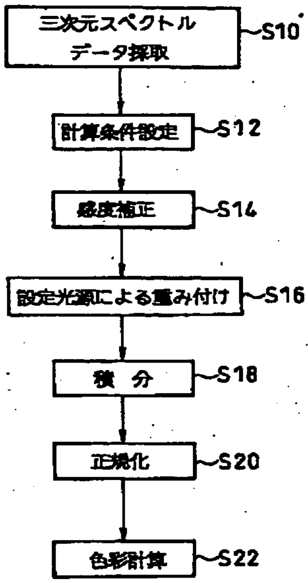
(b)



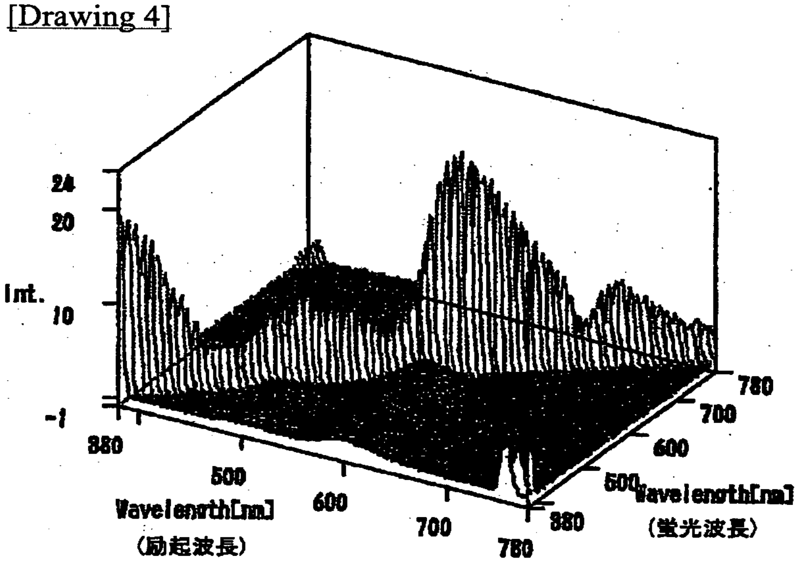
[Drawing 2]



[Drawing 3]



[Drawing 4]



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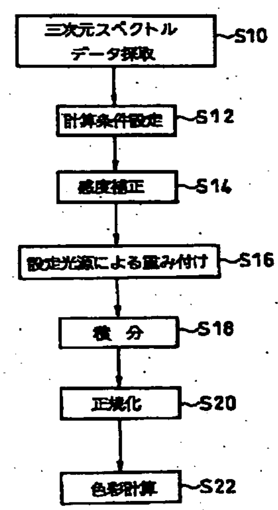
(54)【発明の名称】　蛍光物体色測定方法および装置

(57)【要約】
【課題】　本発明の目的は、蛍光物体色を適正に及び容易に求めることのできる蛍光物体色測定方法を提供することにある。
【解決手段】　分光光度計の照明側分光器を用い光源照明光を所定波長間隔で順次走査し各選択波長光を標準体又は試料に照射し、検出側分光器を用い該照明側分光器での各選択波長毎に所望波長領域を走査し標準体及び試料の三次元の光強度ｽﾍﾟｸﾄﾙﾃﾞｰﾀを得る測定工程(S10)と、色評価用の照明光の相対強度分光分布を指定する計算条件設定工程(S12)と、該工程(S12)での相対強度分布により該工程(S10)で得た試料のﾃﾞｰﾀを重付し(S16)、該工程(S12)での指定照明光下での標準体と試料の発光強度ｽﾍﾟｸﾄﾙﾃﾞｰﾀを求め(S18)、該試料のﾃﾞｰﾀを標準体のﾃﾞｰﾀで除し、標準体を基準にした際の試料の発光反射率ｽﾍﾟｸﾄﾙﾃﾞｰﾀを求め(S20)、該ﾃﾞｰﾀから該工程(S12)での指定照明光下での試料の散乱光及び蛍光による蛍光物体色を表現する色刺激値を得る計算工程(S22)と、を備えたことを特徴とする蛍光物体色測定方法。



【特許請求の範囲】

【請求項１】　分光光度計の所定の測定位置に標準体と、試料を置き換えて設置し、該分光光度計の照明側分光器を用い、光源からの照明光を所定の波長間隔で順次波長走査し、各選択波長の光を標準体又は試料に照射し、該分光光度計の検出側分光器を用い、前記照明側分光器での各選択波長ごとに所望の波長領域を波長走査し、前記光源からの照明光の下での標準体の蛍光及び散乱光による三次元の光強度スペクトルデータと、試料の蛍光及び散乱光による三次元の光強度スペクトルデータを採取する測定工程と、

色の評価に用いる照明光の、前記測定工程で用いられた照明光の強度分光分布を基準にした際の相対強度分光分布を指定する計算条件設定工程と、

前記計算条件設定工程で指定された照明光の相対強度分布情報により、前記測定工程で得られた試料の三次元光強度スペクトルデータを重み付けし、前記計算条件設定工程で指定された照明光の下での試料の散乱光及び蛍光による発光強度スペクトルデータを求め、

前記重み付けされた試料の発光強度スペクトルデータを、前記標準体の三次元光強度スペクトルデータから得られた発光強度スペクトルデータで除し、標準体を基準にした際の試料の散乱光及び蛍光による反射率スペクトルデータとしての発光反射率スペクトルデータを求め、

前記標準体を基準にした際の試料の発光反射率スペクトルデータから、前記計算条件設定工程で指定された照明光の下での、標準体の色を基準にした際の試料の散乱光及び蛍光による蛍光物体色を表現する色刺激値を求める計算工程と、

を備えたことを特徴とする蛍光物体色測定方法。

【請求項２】　請求項１記載の蛍光物体色測定方法において、

前記蛍光物体色を表現するのにＸＹＺ表色系を用いる場合、前記色刺激値としての三刺激値Ｘ，Ｙ，Ｚは、次記数１により表現されることを特徴とする蛍光物体色測定方法。

【数１】

$$X = K\int R(\lambda_{EM})\cdot\bar{x}(\lambda_{EM})\,d\lambda_{EM}$$

$$Y = K\int R(\lambda_{EM})\cdot\bar{y}(\lambda_{EM})\,d\lambda_{EM}$$

$$Z = K\int R(\lambda_{EM})\cdot\bar{z}(\lambda_{EM})\,d\lambda_{EM}$$

$$W(\lambda_{EM}) = \int w(\lambda_{EX},\lambda_{EM})\,d\lambda_{EX}$$

$$F(\lambda_{EM}) = \int f(\lambda_{EX},\lambda_{EM})\cdot S(\lambda_{EX})\,d\lambda_{EX}$$

$$R(\lambda_{EM}) = {F(\lambda_{EM})}\Big/{W(\lambda_{EM})}$$

$$K = 100\Big/\int S(\lambda_{EM})\cdot y(\lambda_{EM})\,d\lambda_{EM}$$

（ここに、ｗ（λ_{EX}，λ_{EM}）：前記測定工程で得られた前記照明側分光器による選択波長λ_{EX}、前記検出側分光器による選択波長λ_{EM}における標準体の三次元の光強度スペクトルデータ

ｆ（λ_{EX}，λ_{EM}）：前記測定工程で得られた前記照明側分光器による選択波長λ_{EX}、前記検出側分光器による選択波長λ_{EM}における試料の三次元の光強度スペクトルデータ

Ｗ（λ_{EM}）：前記計算工程で得られた検出波長λ_{EM}における標準体の発光強度スペクトルデータ

Ｆ（λ_{EM}）：前記計算工程で得られた検出波長λ_{EM}における試料の、前記計算条件設定工程で指定された照明光の下での発光強度スペクトルデータ

Ｒ（λ_{EM}）：前記計算工程で得られた、検出波長λ_{EM}における試料の発光強度スペクトルデータを、検出波長λ_{EM}における標準体の発光強度スペクトルデータで除して得られた、検出波長λ_{EM}における試料の、前記計算条件設定工程で指定された照明光の下での正規化発光強度スペクトルデータ

Ｓ（λ_{EM}）：前記測定工程で用いられた照明光の強度分光分布を基準にした際の前記計算条件設定工程で指定された照明光の相対強度分光分布

ｘ，ｙ，ｚ（λ_{EM}）：前記計算工程で発光反射率スペクトルデータから色刺激値を求める際に用いられるＸＹＺ表色系における等色関数

Ｋ：前記計算工程で発光反射率スペクトルデータから色刺激値を求める際に用いられるＸＹＺ計算の正規化係数）

【請求項３】　測定する波長領域での連続光を発生する連続光源と、

前記連続光源からの光から所望波長の照明光を選択し、所定の測定位置に置かれた標準体又は試料に照射する照明側分光器と、

前記標準体又は試料からの散乱光及び蛍光のうち、所望波長の光を得る検出側分光器と、

前記検出側分光器を出射した光の強度を検出する検出器

と、
標準体及び試料について、照明側分光器での選択波長を所定の波長間隔で順次波長走査し、検出側分光器により、該照明側分光器での各選択波長での三次元の光強度スペクトルデータが得られるように、前記照明側分光器及び検出側分光器の波長走査を制御する波長走査手段と、
前記検出器からの出力値に基づく標準体の三次元の光強度スペクトルデータ、及び試料の三次元の光強度スペクトルデータを記憶するデータ記憶手段と、
色を評価するのに用いる照明光について、前記連続光源の照明光の強度分光分布を基準にした際の相対強度分布情報を記憶する照明光情報記憶手段と、
前記照明光情報記憶手段に相対強度分布情報の記憶された照明光の中から所望の照明光の種類を指定する計算条件設定手段と、
前記計算条件設定手段で指定された照明光の相対強度分布情報を、前記照明光情報記憶手段から得、該相対強度分布情報により、前記データ記憶手段の試料の三次元の光強度スペクトルデータを重み付けし、前記計算条件設定手段で指定された照明光の下での試料の散乱光及び蛍光による発光強度スペクトルデータを求め、
前記重み付けされた試料の発光強度スペクトルデータを、前記標準体の三次元光強度スペクトルデータから得られた発光強度スペクトルデータで除し、前記標準体を基準にした際の、試料の散乱光及び蛍光による反射率スペクトルデータとしての発光反射率スペクトルデータを求め、
前記標準体を基準にした際の試料の散乱光及び蛍光による発光反射率スペクトルデータから、前記計算条件設定手段で指定された照明光の下での、前記標準体の色を基準にした際の試料の散乱光及び蛍光による蛍光物体色を表現する色刺激値を求める計算手段と、
を備えたことを特徴とする蛍光物体色測定装置。
【請求項４】　請求項３記載の蛍光物体色測定装置において、
前記蛍光物体色を表現するのにＸＹＺ表色系を用いる場合、前記色刺激値としての三刺激値Ｘ，Ｙ，Ｚは、次記数２により表現されることを特徴とする蛍光物体色測定装置。
【数２】

$$X = K\int R(\lambda_{EM})\cdot\tilde{x}(\lambda_{EM})\,d\lambda_{EM}$$

$$Y = K\int R(\lambda_{EM})\cdot\tilde{y}(\lambda_{EM})\,d\lambda_{EM}$$

$$Z = K\int R(\lambda_{EM})\cdot\tilde{z}(\lambda_{EM})\,d\lambda_{EM}$$

$$W(\lambda_{EM}) = \int w(\lambda_{EX},\lambda_{EM})\,d\lambda_{EX}$$

$$F(\lambda_{EM}) = \int f(\lambda_{EX},\lambda_{EM})\cdot S(\lambda_{EX})\,d\lambda_{EX}$$

$$R(\lambda_{EM}) = F(\lambda_{EM}) \big/ W(\lambda_{EM})$$

$$K = 100 \Big/ \int S(\lambda_{EM})\cdot y(\lambda_{EM})\,d\lambda_{EM}$$

（ここに、$w(\lambda_{EX}, \lambda_{EM})$：前記照明側分光器での選択波長$\lambda_{EX}$、前記検出側分光器での選択波長$\lambda_{EM}$における前記データ記憶手段の標準体の三次元の光強度スペクトルデータ
$f(\lambda_{EX}, \lambda_{EM})$：前記照明側分光器での選択波長$\lambda_{EX}$、検出側分光器での選択波長$\lambda_{EM}$における前記データ記憶手段の試料の三次元の光強度スペクトルデータ
$W(\lambda_{EM})$：前記計算手段で得られた検出波長λ_{EM}における標準体の発光強度スペクトルデータ
$F(\lambda_{EM})$：前記計算手段で得られた検出波長λ_{EM}における試料の、前記計算条件設定手段で指定された照明光の下での発光強度スペクトルデータ
$R(\lambda_{EM})$：前記計算手段で得られた、検出波長λ_{EM}における試料の発光強度スペクトルデータを検出波長λ_{EM}における標準体の発光強度スペクトルデータで除して得られた、検出波長λ_{EM}の試料の、前記計算条件設定手段で指定された照明光の下での正規化発光強度スペクトルデータ
$S(\lambda_{EM})$：前記連続光源の照明光の強度分光分布を基準にした際の前記計算条件設定手段で指定された照明光の相対強度分光分布
$x, y, z(\lambda_{EM})$：前記計算手段で発光反射率スペクトルデータから色刺激値を求める際に用いられるＸＹＺ表色系における等色関数
Ｋ：前記計算手段で発光反射率スペクトルデータから色刺激値を求める際に用いられるＸＹＺ計算の正規化係数）
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は蛍光物体色測定方法および装置、特にスペクトルデータ採取機構、及びそのスペクトルデータに基づく色彩計算機構の改良に関する。
【０００２】
【従来の技術】一般に物の色は、その物に照射された光

のうち、一部波長領域が吸収され、残部が発射されることにより、看取可能となる。しかし、物体の中にはいわゆる蛍光を発するものがあり、この場合には前記散乱光と蛍光とが加法混色されて看取されることとなり、対象物の色を単純に波長吸収特性から評価することはできない。そこで、従来より、例えばＸＹＺ等の表色系によって、蛍光性の反射物体の色の測定が行なわれている。

【０００３】この蛍光物体色の測定方法は、例えばＪＩＳ Ｚ ８７１７－１９８９に規定されており、その中でも特に正確さを要する場合には例えば２光源蛍光分離方法が用いられる。図１には２光源蛍光分離方法における光学系配置が示されている。例えば同図（ａ）に示す装置１０のように、例えばD_{65}の分光分布に近似した測定用光源１２と、光源１２からの照明光Ｌ１が当てられる常用標準白色板ないし試料１４と、標準白色板又は試料１４からの散乱光及び蛍光Ｌ２のうち、所望の単色光を出射するモノクロメータ１６と、モノクロメータ１６を出射した光の強度を測定する受光器１８を含むものがある。

【０００４】また、同図（ｂ）に示す装置１０´のように、連続スペクトル光源１２´と、モノクロメータ２０とからなる単色光照射装置と、単色光Ｌ１による非分光によって常用標準白色板又は試料１４からの散乱光及び蛍光Ｌ２の全波長成分を一括して測定する非分光観測用受光器１８´を含むものもある。

【０００５】このように前記２光源蛍光分離方法では、何れの場合も一方のモノクロメータと光源部・受光部とを組みあわせて用いることにより、２種類の試料面照明光を用い、全分光放射輝度率と見掛けの分光放射輝度の測定によって、散乱光成分と蛍光成分とを分離・評価して色を求めている。ここで、前記散乱光成分と蛍光成分とを推定値として分離・評価して色を求める際は、光源は例えばD_{65}の分光分布と常に一致しており、経時的な変動がないという仮定を用いていた。

【０００６】また、照明光の紫外領域をカットすれば、常用標準白色体、試料は試料照明光で照明した時に蛍光を発しないという仮定を用いていた。このように前記２光源蛍光分離方法は勿論、ＪＩＳ Ｚ ８７１７－１９８９に規定された他の方法についても推定またはかなり大胆な近似を用いて蛍光物体色を求めていた。

【０００７】

【発明が解決しようとする課題】しかしながら、最も厳密とされる前記２光源蛍光分離方法においても、前記蛍光物体色推定の正確さ、再現性等は改善の余地が残されていたものの、これを解決することのできる適切な技術が存在しなかった。また、照明光の種類によって観測される色彩がどのように変化するか等の詳細な分析は不可能であった。

【０００８】つまり、例えばD_{65}の分光分布に近似した照明光を用いた場合、昼光の照明時に見える色しか推定できず、他の光の照明を行なった時の色を知りたい場合には、照明光を変えて、再測定、再計算を一からやり直す必要があり、面倒であった。本発明は前記従来技術の課題に鑑みなされたものであり、その目的は蛍光物体色を正確に及び容易に求めることのできる蛍光物体色測定方法および装置を提供することにある。

【０００９】

【課題を解決するための手段】本発明者が前記正確さ、再現性の向上について鋭意検討を重ねた結果、推定結果の正確さ、再現性を低減している要因としては、測定用光源から発生する照明光の分光分布は経時的な変動がない、照明光の紫外領域の光をカットすれば、標準体、試料は蛍光を発しないという仮定により反射成分と蛍光成分を分離していることにあることを解明した。

【００１０】本発明者によれば、同一の装置、同一の試料でも、例えば光源のランプが古い時と新しい時とでは必ずしも照明光の分光分布が一致しない。また、標準体、試料には可視領域でも蛍光を発するものもある。そこで、本発明者は、従来一般的な前記仮定を用いて散乱光成分と蛍光成分とを分離して色を評価する手法に代えて、実際に分光光度計の照明側分光器及び検出側分光器の波長走査を行ないながら、散乱光及び蛍光による三次元の光強度スペクトルデータの採取を行なう。

【００１１】そして、このような三次元の光強度スペクトルデータから後述する計算により、散乱光成分及び蛍光成分を分離することなく、一括して色を評価することにより、前記推定結果の正確さ、再現性等の改善が図られることを見出し、本発明を完成するに至った。すなわち、前記目的を達成するために本発明にかかる蛍光物体色測定方法は、測定工程と、計算条件設定工程と、計算工程と、を備えることを特徴とする。

【００１２】ここで、前記測定工程は、分光光度計の所定の測定位置に標準体と、試料を置き換えて設置し、前記分光光度計の照明側分光器を用い、光源からの照明光を所定の波長間隔で順次波長走査し、各選択波長の光を標準体又は試料に照射し、前記分光光度計の検出側分光器を用い、該照明側分光器での各選択波長ごとに所望の波長領域を波長走査し、前記光源からの照明光の下での標準体の蛍光及び散乱光による三次元の光強度スペクトルデータと、試料の蛍光及び散乱光による三次元の光強度スペクトルデータを採取する。

【００１３】また、前記計算条件設定工程は、色の評価に用いる照明光の、前記測定工程で用いられた照明光の強度分光分布を基準にした際の相対強度分光分布を指定する。前記計算工程は、前記計算条件設定工程で指定された照明光の相対強度分布情報により、前記測定工程で得られた試料の三次元光強度スペクトルデータを重み付けし、前記計算条件設定工程で指定された照明光の下での試料の散乱光及び蛍光による発光強度スペクトルデータを求める。そして、前記重み付けされた試料の発光強

度スペクトルデータを、前記標準体の三次元の光強度スペクトルデータから得られた発光強度スペクトルデータで除し、標準体を基準にした際の試料の散乱光及び蛍光による反射率スペクトルデータとしての発光反射率スペクトルデータを求める。つぎに、前記標準体の発光反射率スペクトルデータを基準にした際の試料の発光反射率スペクトルデータから、前記計算条件設定工程で指定された照明光の下での、前記標準体の色を基準にした際の試料の散乱光及び蛍光による蛍光物体色を表現する色刺激値を求める。

【００１４】なお、本発明において、前記蛍光物体色を表現するのにＸＹＺ表色系を用いる場合、前記色刺激値としての三刺激値Ｘ，Ｙ，Ｚは、次記数３により表現されることが好適である。

【数３】

$$X = K\int R(\lambda_{EM})\cdot\bar{x}(\lambda_{EM})d\lambda_{EM}$$

$$Y = K\int R(\lambda_{EM})\cdot\bar{y}(\lambda_{EM})d\lambda_{EM}$$

$$Z = K\int R(\lambda_{EM})\cdot\bar{z}(\lambda_{EM})d\lambda_{EM}$$

$$W(\lambda_{EM}) = \int w(\lambda_{EX},\lambda_{EM})d\lambda_{EX}$$

$$F(\lambda_{EM}) = \int f(\lambda_{EX},\lambda_{EM})\cdot S(\lambda_{EX})d\lambda_{EX}$$

$$R(\lambda_{EM}) = F(\lambda_{EM}) \big/ W(\lambda_{EM})$$

$$K = 100 \Big/ \int S(\lambda_{EM})\cdot y(\lambda_{EM})d\lambda_{EM}$$

【００１５】（ここに、ｗ（λ_{EX}，λ_{EM}）：前記測定工程で得られた前記照明側分光器での選択波長λ_{EX}、前記検出側分光器での選択波長λ_{EM}における標準体の三次元の光強度スペクトルデータ

ｆ（λ_{EX}，λ_{EM}）：前記測定工程で得られた前記照明側分光器での選択波長λ_{EX}、検出側分光器での選択波長λ_{EM}における試料の三次元の光強度スペクトルデータ

Ｗ（λ_{EM}）：前記計算工程で得られた検出波長λ_{EM}における標準体の発光強度スペクトルデータ

Ｆ（λ_{EM}）：前記計算工程で得られた検出波長λ_{EM}における試料の、前記計算条件設定工程で指定された照明光の下での発光強度スペクトルデータ

Ｒ（λ_{EM}）：前記計算工程で得られた、検出波長λ_{EM}における試料の発光強度スペクトルデータを、検出波長λ_{EM}における標準体の発光強度スペクトルデータで除して得られた、検出側波長λ_{EM}における試料の、前記計算条件設定工程で指定された照明光の下での正規化発光強度スペクトルデータ

Ｓ（λ_{EM}）：前記測定工程で用いられた照明光の強度分光分布を基準にした際の前記計算条件設定工程で指定された照明光の相対強度分光分布

ｘ，ｙ，ｚ（λ_{EM}）：前記計算工程で発光反射率スペクトルデータから色刺激値を求める際に用いられるＸＹＺ表色系における等色関数

Ｋ：前記計算工程で発光反射率スペクトルデータから色刺激値を求める際に用いられるＸＹＺ計算の正規化係数）

【００１６】また、前記目的を達成するために本発明にかかる蛍光物体色測定装置は、連続光源と、照明側分光器と、検出側分光器と、検出器と、波長走査手段と、データ記憶手段と、照明光情報記憶手段と、計算条件設定手段と、計算手段と、を備えることを特徴とする。ここで、前記連続光源は、測定する波長領域での連続光を発生する。また、前記照明側分光器は、前記連続光源からの照明光から所望波長の照明光を選択し、所定の測定位置に置かれた標準体又は試料に照射する。前記検出側分光器は、前記標準体又は試料からの散乱光及び蛍光のうち、所望波長の光を得る。

【００１７】前記検出器は、前記蛍光側分光器を出射した光の強度を検出する。前記波長走査手段は、標準体及び試料について、照明側分光器での選択波長を所定の波長間隔で順次波長走査し、検出側分光器により、該照明側分光器で選択された各波長での三次元の光強度スペクトルデータが得られるように、前記照明側分光器及び検出側分光器の波長走査を制御する。

【００１８】前記データ記憶手段は、前記検出器からの出力値に基づく標準体の三次元の光強度スペクトルデータ、及び試料の三次元の光強度スペクトルデータを記憶する。前記照明光情報記憶手段は、色の評価に用いる照明光について、前記連続光源の照明光の強度分光分布を基準にした際の相対強度分布情報を記憶する。前記計算条件設定手段は、前記照明光情報記憶手段に相対強度分布情報の記憶された照明光の中から色の評価に用いる照明光の種類を指定する。

【００１９】前記計算手段は、前記計算条件設定手段で指定された照明光の相対強度分布情報を、前記照明光情報記憶手段から得、該相対強度分布情報により、前記データ記憶手段の試料の三次元の光強度スペクトルデータを重み付けし、前記計算条件設定手段で指定された照明光の下での試料の散乱光及び蛍光による発光強度スペクトルデータを求める。そして、前記重み付けされた試料の発光強度スペクトルデータを、前記標準体の三次元の光強度スペクトルデータから得られた発光強度スペクトルデータで除し、前記標準体を基準にした際の、試料の散乱光及び蛍光による反射率スペクトルデータとしての発光反射率スペクトルデータを求める。つぎに、前記標準体を基準にした際の試料の散乱光及び蛍光による発光反射率スペクトルデータから、前記計算条件設定手段で指定された照明光の下での、前記標準体の色を基準にした際の試料の散乱光及び蛍光による蛍光物体色を表現す

る色刺激値を求める。

【0020】なお、本発明において、前記蛍光物体色を表現するのにＸＹＺ表色系を用いる場合、前記色刺激値としての三刺激値Ｘ，Ｙ，Ｚは、次記数４により表現されることが好適である。

【数４】

$$X = K\int R(\lambda_{EM})\cdot\bar{x}(\lambda_{EM})\,d\lambda_{EM}$$

$$Y = K\int R(\lambda_{EM})\cdot\bar{y}(\lambda_{EM})\,d\lambda_{EM}$$

$$Z = K\int R(\lambda_{EM})\cdot\bar{z}(\lambda_{EM})\,d\lambda_{EM}$$

$$W(\lambda_{EM}) = \int w(\lambda_{EX},\lambda_{EM})\,d\lambda_{EX}$$

$$F(\lambda_{EM}) = \int f(\lambda_{EX},\lambda_{EM})\cdot S(\lambda_{EX})\,d\lambda_{EX}$$

$$R(\lambda_{EM}) = F(\lambda_{EM}) / W(\lambda_{EM})$$

$$K = 100 \Big/ \int S(\lambda_{EM})\cdot y(\lambda_{EM})\,d\lambda_{EM}$$

【0021】（ここに、ｗ（λ_{EX}，λ_{EM}）：前記照明側分光器での選択波長λ_{EX}、前記検出側分光器での選択波長λ_{EM}における前記データ記憶手段の標準体の三次元の光強度スペクトルデータ

ｆ（λ_{EX}，λ_{EM}）：前記照明側分光器での選択波長λ_{EX}、前記検出側分光器での選択波長λ_{EM}における前記データ記憶手段の試料の三次元の光強度スペクトルデータ

Ｗ（λ_{EM}）：前記計算手段で得られた検出波長λ_{EM}における標準体の発光強度スペクトルデータ

Ｆ（λ_{EM}）：前記計算手段で得られた検出波長λ_{EM}における試料の、前記計算条件設定手段で指定された照明光による発光強度スペクトルデータ

Ｒ（λ_{EM}）：前記計算手段で得られた、検出波長λ_{EM}における試料の発光強度スペクトルデータを、検出波長λ_{EM}における標準体の発光強度スペクトルデータ除して得られた、検出波長λ_{EM}における試料の、前記計算条件設定手段で指定された照明光の下での正規化発光強度スペクトルデータ

Ｓ（λ_{EM}）：前記連続光源の照明光に対する強度分光分布を基準にした際の前記計算条件設定手段で指定された照明光の相対強度分光分布

ｘ，ｙ，ｚ（λ_{EM}）：前記計算手段で発光反射率スペクトルデータから色刺激値を求める際に用いられるＸＹＺ表色系における等色関数

Ｋ：前記計算手段で発光反射率スペクトルデータから色刺激値を求める際に用いられるＸＹＺ計算の正規化係数）

【0022】ここにいう計算条件設定工程および手段では、色の評価に用いる照明光のほかに、色を計算する際に必要な条件であれば、他の条件、例えば視野角、波長間隔等も設定可能とする。また、ここにいう蛍光及び散乱光とは、照明光による試料又は標準体の正反射方向からそれらの光を観察したものでなく、それ以外の任意方向から観察したものをいう。

【0023】また、ここにいう発光とは、何等かの発光体自身から発せられた光をいうのではなく、照明光による試料又は標準体からの蛍光を意味する。また、ここにいう発光強度スペクトルデータとは、照明光による試料又は標準体からの蛍光のみによるものをいうのではなく、照明光による試料又は標準体からの散乱光によるものを含めたものをいう。また、ここにいう発光反射率スペクトルデータとは、照明光による試料又は標準体からの蛍光のみによるものと、照明光による試料又は標準体からの散乱光によるものを含めたものをいう。

【0024】

【発明の実施の形態】以下、図面に基づき本発明の好適な実施形態について説明する。図２には本発明の一実施形態にかかる蛍光物体色測定装置の概略構成が示されている。なお、前記図１と対応する部分には符号１００を加えて示し説明を省略する。

【0025】同図に示す蛍光物体色測定装置１１０は、蛍光分光光度計（分光光度計）１２２と、コンピュータ（計算手段）１２４を含む。前記蛍光分光光度計１２２は、連続光源１１２と、励起側分光器（照明側分光器）１２０と、蛍光側分光器（検出側分光器）１１６と、検出器１１８を含む。ここで、前記連続光源１１２は、測定する波長領域での連続光を発生する。また、前記励起側分光器１２０は、光源１１２からの光の中から所望波長の照明光Ｌ１を選択し、所定の測定位置に置かれた白色板（標準体）又は試料１１４に照射する。

【0026】前記蛍光側分光器１１６は、前記白色板又は試料１１４からの散乱光及び蛍光による光Ｌ２の中から所望波長の光を得る。前記検出器１１８は、蛍光側分光器１１６を出射した光の強度を検出する。前記コンピュータ１２４は、データ記憶手段１２６と、照明光情報記憶手段１２８と、計算条件設定手段１３０と、ＣＰＵ１３２を含む。

【0027】前記データ記憶手段１２６は、蛍光分光光度計１２２の励起側分光器１２０及び蛍光側分光器１１６を波長走査して得られた白色板および試料の三次元蛍光スペクトルデータ（三次元の光強度スペクトルデータ）を記憶する。前記照明光情報記憶手段１２８は、色の評価に用いる種々の照明光の相対強度分光分布、つまり前記連続光源の照明光の強度分光分布を基準にした際の強度分光分布情報をあらかじめ記憶する。

【0028】前記計算条件設定手段１３０は、色の計算の際に必要となる表色系、視野角、照明光および波長間隔などを設定する。前記ＣＰＵ１３２は、色を計算する際は、計算条件設定手段１３０で指定された照明光の相

対強度分布情報を照明光情報記憶手段１２８から得る。そして、このCPU１３２は、この指定照明光の相対強度分布情報によりデータ記憶手段１２６の試料の三次元蛍光スペクトルデータを重み付けする。これにより、指定照明光の下での試料の発光強度スペクトルデータが得られる。

【００２９】また、このCPU１３２は、データ記憶手段１２６の白色板の三次元蛍光スペクトルデータから、白色板の発光強度スペクトルデータを計算する。このCPU１３２は、前述のようにして得られた白色板の発光強度スペクトルデータと試料の発光強度スペクトルデータの比、つまり等価反射スペクトルデータを求める。

【００３０】そして、このCPU１３２は、この等価反射スペクトルデータに基づき、前記指定照明光の下での、試料の散乱光及び蛍光による蛍光物体色をXYZ表色系の三刺激値により表現する。なお、コンピュータ１２４及び波長走査手段１３４，１３６は、励起側分光器１２０および蛍光側分光器１１６の波長走査を行ない、所望の波長範囲の三次元蛍光スペクトルデータが得られるように、励起側分光器１２０および蛍光側分光器１１６の波長走査を制御する。

【００３１】本実施形態にかかる蛍光物体色測定装置１１０は概略以上のように構成され、以下にその作用について説明する。まず、通常、蛍光物体色を求める際は、光源からの照明光の強度分光分布は例えばD_{65}の強度分光分布と常に一致しており、経時的な変動がないという仮定を用いていた。

【００３２】また、照明光の紫外領域をカットすれば、標準白色体、試料は試料照明光で照明した時に蛍光を発しないという仮定を用いて、散乱光成分と蛍光成分とを分離して色を評価していた。しかしながら、このような仮定を用いて散乱光成分と蛍光成分とを分離した場合には、推定結果の正確さ、再現性等のより一層の改善は望めない。

【００３３】そこで、本実施形態では、推定結果の正確さ、再現性等の改善を図るため、前記従来方式、つまり前記従来の仮定を用いて散乱光成分と蛍光成分とを分離して色を評価する手法に代えて、実際に蛍光分光光度計１２２の励起側分光器１２０及び蛍光側分光器１１６の波長走査を行ないながら、散乱光及び蛍光による三次元蛍光スペクトルデータの採取を行なう。そして、このような三次元蛍光スペクトルデータから後述する計算により、散乱光成分及び蛍光成分を分離することなく一括して色を評価することとした。以下にその具体的な作用について図３を参照しつつ説明する。

【００３４】<u>三次元蛍光スペクトルデータ採取</u>

蛍光分光光度計１２２の励起側分光器１２０及び蛍光側分光器１１６の波長走査を行ない、適切な条件で、白色板の散乱光及び蛍光の影響を含む三次元蛍光スペクトルデータを測定する。その後、この白色板を試料に置き換えて、試料の散乱光及び蛍光の影響を含む三次元蛍光スペクトルデータ（図４参照）を測定する（S１０）。

【００３５】このようにして採取された三次元蛍光スペクトルデータには、散乱光及び蛍光が含まれている。なお、このような三次元蛍光スペクトルデータを採取するには、励起側分光器１２０での選択励起波長を例えば３００nm、３１０nm、３２０、…７８０nmと一定のステップ、１０nm間隔で変化させ、各選択励起波長での蛍光スペクトルを蛍光側分光器１１６を波長走査して測定する。

【００３６】例えば、本実施形態では、励起側分光器１２０での励起波長間隔を３８０nmから７８０nmとする。そして、励起側分光器１２０での励起波長間隔は例えば５nm又は１０nmとし、蛍光側分光器での蛍光波長間隔は例えば１nmとする。励起・蛍光バンド幅は同一とし、励起波長間隔と一致させる。

【００３７】蛍光側分光器１１６による蛍光波長範囲は、例えば励起波長—バンド幅×２～励起波長×２－バンド幅×２とする。ただし、その最大範囲は例えば３８０nm～７８０nmとして、三次元蛍光スペクトルデータを採取する。

【００３８】<u>計算条件設定</u>

そして、蛍光分光光度計１２２による三次元スペクトルデータ採取後、コンピュータ１２４は、表色系、視野角、光源（照明光）および波長間隔等の計算条件を指定する（S１２）。

【００３９】（１）表色系の選択

コンピュータ１２４は、試料の蛍光物体色を表現する表色系を選択する。例えばXYZ、Lab、L＊a＊b＊、L＊u＊b＊，L＊H＊C＊、Munsellから選択可能とする。

【００４０】（２）視野角

コンピュータ１２４は、試料の三次元蛍光スペクトルデータから蛍光物体色の三刺激値（XYZ）を計算する際の視野角、観測者の目に対して張る角の選択を行う。例えば２度視野、および１０度視野から選択可能とする。

【００４１】（３）照明光の選択

コンピュータ１２４は、試料の三次元蛍光スペクトルデータから蛍光物体色の三刺激値を計算する際の照明光の種類の選択を行う。例えばJIS Z ８７２０－１９８３に定められた標準の光A、標準の光D_{65}、標準の光Cおよび補助標準の光Bから選択可能とする。

【００４２】（４）波長間隔

試料の三次元蛍光スペクトルデータから蛍光物体色の三刺激値を求める際の波長間隔、つまり後述する積算での波長間隔の選択を行う。例えば５nmおよび１０nmから選択可能とする。

【００４３】<u>励起側分光器の感度補正</u>

コンピュータ１２４は、得られた三次元蛍光スペクトルデータを、励起光強度及び励起側分光器１２０の感度で

正規化する（Ｓ１４）。すなわち、本実施形態では、蛍光側と励起側に独立した分光器１２０，１１６を備える。このため、励起側の信号をＥｘ（λ_{EX}）、蛍光側の信号をＥｍ（λ_{EM}）とすると、記録される蛍光強度Ｆ（λ_{EX}、λ_{EM}）は次記数５で示される値となる。もし、励起側分光器１２０に波長特性が無ければこの値を直接使用できるが、実際には波長により感度が異なるので、本実施形態では、このような補正を行う。

【００４４】

【数５】$F(\lambda_{EX}、\lambda_{EM}) = Em(\lambda_{EM}) / Ex(\lambda_{EX})$

波長λ_{EX}における励起側分光器の感度ＰＤ（λ_{EX}）を乗じることで補正を行う。

【００４５】<u>色の評価に用いる照明光による重み付け</u>

コンピュータ１２４は、選択された照明光の相対強度分光分布での重み付けを行う（Ｓ１６）。なお、この照明光の相対強度分布、つまりエネルギ分布は、例えばＪＩＳに定められた標準の光Ａ、標準の光Ｄ６５、標準の光Ｃ、補助標準の光Ｂ等のものをそのまま用いることができる。

【００４６】コンピュータ１２４は、前述のようにして選択された照明光の各波長の相対強度を、データ記憶手段１２６の試料の三次元蛍光スペクトルデータに乗じ、色の評価に用いる照明光による重み付けを行う。これにより、励起エネルギーが指定された照明光とした時の各励起波長における蛍光スペクトルを得ることができる。なお、白色板については、計算条件設定で選択された照明光による重み付けは行なわない。

【００４７】<u>積分</u>

コンピュータ１２４は、重み付けした各蛍光波長におけるデータを、前記計算条件設定で指定された波長間隔で足し合わせ（Ｓ１８）、３８０ｎｍ～７８０ｎｍの三次元蛍光スペクトルデータとする。この処理によって、励起エネルギーが指定された照明光とした時の発光強度スペクトルデータを得ることができる。

【００４８】<u>正規化</u>

前記足し合わせた発光強度スペクトルデータは、選択された照明光による散乱光を含めた各波長での発光強度、すなわち発光強度スペクトルデータを示す。試料の発光強度スペクトルデータを、白色板の発光強度スペクトルデータで除したスペクトルデータは、蛍光を含めた試料の正規化された発光強度スペクトルデータとなる（Ｓ２０）。

【００４９】前述のような積分によって得られた試料の発光強度スペクトルデータは、色の評価に用いる照明光の重み付けがされている。白色板の発光強度スペクトルデータとが得られると、その比が反射率と等価となる。本実施形態ではこれを等価反射スペクトルデータという。

【００５０】<u>色彩計算</u>

コンピュータ１２４は、この等価反射スペクトルデータに関して、計算条件設定で設定された視野角、波長間隔でＸＹＺ表色系の三刺激値Ｘ，Ｙ，Ｚを算出し、指定された表色系で表示する。この正規化等価反射スペクトルデータと等色関数とから、前記計算条件設定で指定された照明光の下での散乱光及び蛍光による物体色を表現する色刺激値を計算する（Ｓ２２）。

【００５１】なお、ＸＹＺ表色系における蛍光物体色の三刺激値Ｘ，Ｙ，Ｚは、次記数６で与えられる。

【数６】

$$X = K\int_{380}^{780} R(\lambda_{EM})\cdot\bar{x}(\lambda_{EM})\,d\lambda_{EM}$$

$$Y = K\int_{380}^{780} R(\lambda_{EM})\cdot\bar{y}(\lambda_{EM})\,d\lambda_{EM}$$

$$Z = K\int_{380}^{780} R(\lambda_{EM})\cdot\bar{z}(\lambda_{EM})\,d\lambda_{EM}$$

$$W(\lambda_{EM}) = \int_{300}^{780} w(\lambda_{EX},\lambda_{EM})\,d\lambda_{EX}$$

$$F(\lambda_{EM}) = \int_{300}^{780} f(\lambda_{EX},\lambda_{EM})\cdot S(\lambda_{EX})\,d\lambda_{EX}$$

$$R(\lambda_{EM}) = {F(\lambda_{EM})}\Big/{W(\lambda_{EM})}$$

$$K = 100\Big/\int_{380}^{780} S(\lambda_{EM})\cdot y(\lambda_{EM})\,d\lambda_{EM}$$

【００５２】ここに、ｗ（λ_{EX}，λ_{EM}）：前記データ記憶手段１２６に記憶された励起波長λ_{EX}、蛍光波長λ_{EM}の白色板の三次元蛍光スペクトルデータ、

ｆ（λ_{EX}，λ_{EM}）：前記データ記憶手段１２６に記憶された励起波長λ_{EX}、蛍光波長λ_{EM}の試料の三次元蛍光スペクトルデータ、

Ｗ（λ_{EM}）：前記積分で得られた波長λ_{EM}の白色板の発光強度スペクトルデータ、

Ｆ（λ_{EM}）：前記重み付け、積分で得られた波長λ_{EM}の試料の照明光による発光強度スペクトルデータ、

Ｒ（λ_{EM}）：前記正規化で得られた波長λ_{EM}の試料の照明光による正規化発光強度スペクトルデータ、

Ｓ（λ_{EM}）：前記色彩計算に用いる照明光の波長分散（相対強度分光分布）、

ｘ，ｙ，ｚ（λ_{EM}）：前記色彩計算でのＸＹＺ表色系における等色関数、

Ｋ：前記色彩計算でのＸＹＺ計算の正規化係数。

【００５３】なお、本実施形態において、三次元蛍光スペクトルデータは、励起エネルギー一定で補正されている必要がある。このように本実施形態にかかる蛍光物体色測定装置１１０によれば、実際に蛍光分光光度計１２２の励起側分光器１２０及び蛍光側分光器１１６の波長走査を行ない、白色板と試料１４の散乱光及び蛍光による三次元蛍光スペクトルデータを採取してデータ記憶手段１２６に記憶しておく。

【0054】これにより、計算条件設定で指定された表色系、視野、光源（照明光）、波長間隔に従って、コンピュータ124により、白色板と試料の三次元蛍光スペクトルデータから蛍光物体色を表現する色刺激値を計算可能とすることとした。この結果、本実施形態にかかる蛍光物体色測定装置110によれば、実際に蛍光分光光度計により測定して得られた、散乱光及び蛍光による三次元蛍光スペクトルデータを採取できる。

【0055】そして、このような三次元蛍光スペクトルデータから計算により、散乱光成分及び蛍光成分を分離することなく一括して色を評価できるので、従来方式、つまり従来一般的な仮定を用いて散乱光成分及び蛍光成分を分離して色を評価した場合に比較し、色の推定結果の正確さの向上が図られる。

【0056】ここで、従来方式を用いた場合、例えばD_{65}の分光分布に近似した照明光を用いたのであれば、昼光の照明を行なった時に見える色しか推定できず、他の光の照明を行なった時の色を知りたい場合には、実際に照明光を変えて再測定・再計算という一連の工程を一からやり直す必要があり、面倒であった。

【0057】これに対し、本実施形態にかかる蛍光物体色測定装置110によれば、白色板と試料の三次元蛍光スペクトルデータをデータ記憶手段126に一旦記憶してしまえば、色を評価する照明光を変化させた時の色彩を、実際に照明光を変えて再測定を行うことなく、コンピュータ124による再計算だけで求めることが可能である。

【0058】したがって、他の照明光で見た時の色を計算だけで容易に推定可能となる。しかも、照明光を変化させた時の色彩を、実際に照明光を変えて再測定を行うことなく、コンピュータ124による再計算だけで求めることができるので、光源のランプの劣化等の影響を受けることもない。これにより、本実施形態にかかる蛍光物体色測定装置110によれば、従来方式に比較し、種々の照明光の下での、散乱光及び蛍光による色をより容易に及び適正に推定可能となる。

【0059】以上のように本実施形態にかかる蛍光物体色測定装置110によれば、蛍光分光光度計122の励起側及び蛍光側分光器120，116の波長走査を行ない、白色板と試料の散乱光及び蛍光による三次元蛍光スペクトルデータをデータ記憶手段126に採取しておけば、計算条件設定工程で指定された表色系、視野、光源、波長間隔等に従って、データ記憶手段126にある白色板と試料の三次元蛍光スペクトルデータから、所望の照明光の下での試料の散乱光及び蛍光による蛍光物体色を計算可能とすることとした。

【0060】この結果、本実施形態にかかる蛍光物体色測定装置110によれば、実際に蛍光分光光度計を用いて得られた、散乱光及び蛍光による三次元蛍光スペクトルデータを採取できる。そして、このような三次元蛍光スペクトルデータから計算により、散乱光成分及び蛍光成分を分離することなく、一括して色を評価できるので、従来方式、つまり従来一般的な仮定を用いて散乱光成分及び蛍光成分を分離して色を評価した場合に比較し、色の推定結果の正確さの向上が図られる。

【0061】しかも、本実施形態にかかる蛍光物体色測定装置110によれば、白色板と試料の三次元蛍光スペクトルデータをデータ記憶手段126に採取してあるので、照明光を変化させた時の色彩を、実際に照明光を変えて再測定を行うことなく、コンピュータ124による再計算だけで求めることができる。したがって、種々の照明光で見た時の色を計算だけで推定することができる。

【0062】なお、前記構成では蛍光物体色を表現するのにＸＹＺ表色系を用いた例について説明したが、本発明の蛍光物体色測定方法および装置は、これに限定されるものではなく、他の表色系を用いることも可能である。また、前記構成では本発明の分光光度計として蛍光分光光度計を用いた例について説明した。ここで、本来、蛍光分光光度計は蛍光のみを観測するものである。

【0063】しかしながら、本実施形態では、蛍光分光光度計を用いて照明光による試料又は標準体の散乱光と蛍光の両者を観測している。したがって、本実施形態でいう励起側分光器で選択される励起波長は、照明光の波長をいう。また本実施形態でいう蛍光側分光器で選択される蛍光波長は、蛍光波長そのものをいうのではなく、試料又は白色板からの蛍光及び散乱光を含めた光の波長をいう。

【0064】また、前記構成では、本発明の三次元光強度スペクトルデータを三次元蛍光スペクトルデータと表現した例について説明した。ここで、本来、蛍光スペクトルデータは蛍光のみを観測して得られるものである。しかしながら、本実施形態でいう三次元蛍光スペクトルデータとは、照明光による試料又は標準体の蛍光のみによるものをいうのではなく、照明光による試料又は標準体の散乱光によるものを含めたものをいう。

【0065】

【発明の効果】以上のように本発明にかかる蛍光物体色測定方法および装置によれば、実際に分光光度計を用いて照明側分光器及び検出側分光器の波長走査を行ない、標準体と試料を置き換え、散乱光及び蛍光による三次元の光強度スペクトルデータを採取し（測定工程）、色の評価に用いる照明光の相対強度分光分布を指定し（計算条件設定工程および手段）、標準体の三次元の光強度スペクトルデータと試料の三次元の光強度スペクトルデータから計算により、所望の照明光の下での散乱光及び蛍光による物体色を表現する色刺激値を求めることとした（計算工程および手段）。この結果、本発明にかかる蛍光物体色測定方法および装置によれば、実際に照明側分光器及び検出側分光器を備えた分光光度計を用いて得ら

れた、散乱光及び蛍光による三次元の光強度スペクトルデータを採取できる。そして、このような三次元の光強度スペクトルデータから計算により、散乱光成分及び蛍光成分を分離することなく一括して色を評価できるので、従来方式、つまり従来一般的な仮定を用いて散乱光成分及び蛍光成分を分離して色を評価した場合に比較し、色の推定結果の正確さの向上が図られる。さらに、本発明にかかる蛍光物体色測定方法および装置によれば、標準体と試料の三次元の光強度スペクトルデータをデータ記憶手段に記憶してあるので、色の評価に用いる照明光を変化させた時の色の変化を実際に再測定を行うことなく、再計算だけで容易に求めることができる。したがって、本発明にかかる蛍光物体色測定方法および装置によれば、種々の照明光の下での色を計算だけで推定することができるので、所望の照明光を発生する光源のランプの劣化等の影響をも受けることない。これにより、種々の照明光の下での色の評価を容易に行なうことができると共に、再現性の向上が図られる。

【図面の簡単な説明】

【図１】従来の蛍光物体色測定装置の一例である。

【図２】本発明の一実施形態にかかる蛍光物体色測定装置の概略構成の説明図である。

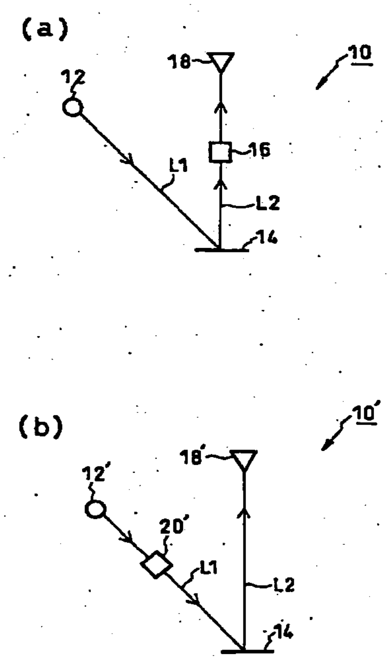
【図３】図２に示した蛍光物体色測定装置の処理の流れを示すフローチャートである。

【図４】図２に示した蛍光物体色測定装置により得られた三次元蛍光スペクトルデータの一例である。

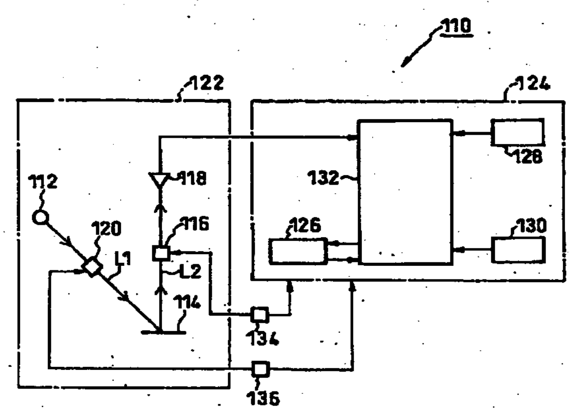
【符号の説明】

１１０…蛍光物体色測定装置
１１２…光源
１１４…白色板（標準体）及び試料
１１６…励起側分光器（照明側分光器）
１１８…検出器
１２０…蛍光側分光器（検出側分光器）
１２２…蛍光分光光度計（分光光度計）
１２４…コンピュータ（計算手段）
１２６…データ記憶手段
１２８…照明光情報記憶手段
１３０…計算条件設定手段
１３４，１３６…波長走査手段

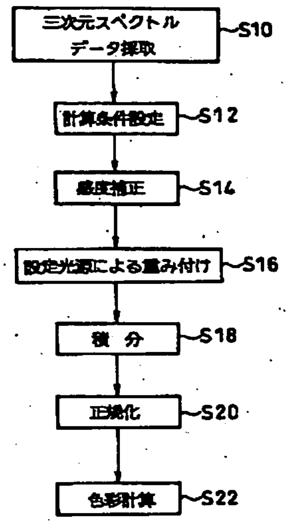
【図１】



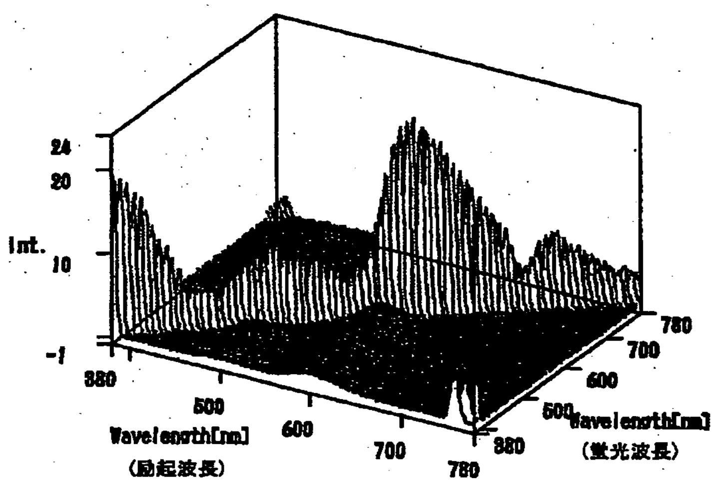
【図２】



【図3】


三次元スペクトル
データ採取
S10
計算条件設定
S12
感度補正
S14
設定光源による重み付け
S16
積 分
S18
正規化
S20
色彩計算
S22

【図4】


24
20
Int.
10
-1
380
500
600
700
780
Wavelength[nm]
(励起波長)
780
700
600
500
380
Wavelength[nm]
(蛍光波長)